Net primary productivity of macrophyte communities after ten growing seasons in experimental marshes

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Introduction

Direct measurements of macrophyte net primary productivity (NPP) were first made at the experimental wetland basins at the Olentangy River Wetland Research Park (ORWRP) in 1997. This study in 2003 represents the seventh set of such measurements. Before 1997 (the fourth growing season), harvesting was not considered a good option when vegetation was just getting started in the basins.

Methods

Aboveground net primary productivity (NPP) was estimated by harvesting peak biomass at the end of the growing season on August 14-15, 2003 at selected stations in the two experimental wetland basins at the ORWRP (Figure 1). The same stations established from the boardwalk system in 1997 were used (Mitsch and Bouchard, 1998). To avoid harvesting the exact same spots, quadrats were not established at points were there had been harvesting in previous years. In each station, we used 1-m^2 quadrats to delineate the area of vegetation for harvest. When no vegetation was present, the station was skipped. Overall, there are potentially 22 stations in each wetland but a maximum of 16 sites are harvested in each basin. Sixteen quadrats were sampled in Wetland 1 and 10 quadrats were sampled in Wetland 2. The only location where there were not sufficient locations for harvesting the maximum number of stations were in the outflow half (south half) of Wetland 2 where extensive herbivory had occurred during the past year. Eight out of a possible eight plots were sampled in the northern half (inflow area) but only two out of a possible eight plots in the southern half of Wetland 2.

In each quadrat, plants were clipped at ground level (the water was lowered in the wetlands to make sampling easier and to allow rapid recovery of the clipped plants). Samples were segregated both by quadrat and by species, placed in plastic bags and weighed in the field with a hanging balance (accuracy ± 40 g). Sub-samples were taken to the laboratory where both wet weight and dry weight (dried at 105°F for 48 hours) were determined to estimate dry/wet ratios. Average ratios for each species were multiplied by total wet weight of each species in a quadrat to estimate total dry weight production. The sum of all species in a quadrat was the estimated peak biomass and hence annual aboveground net primary productivity (NPP).

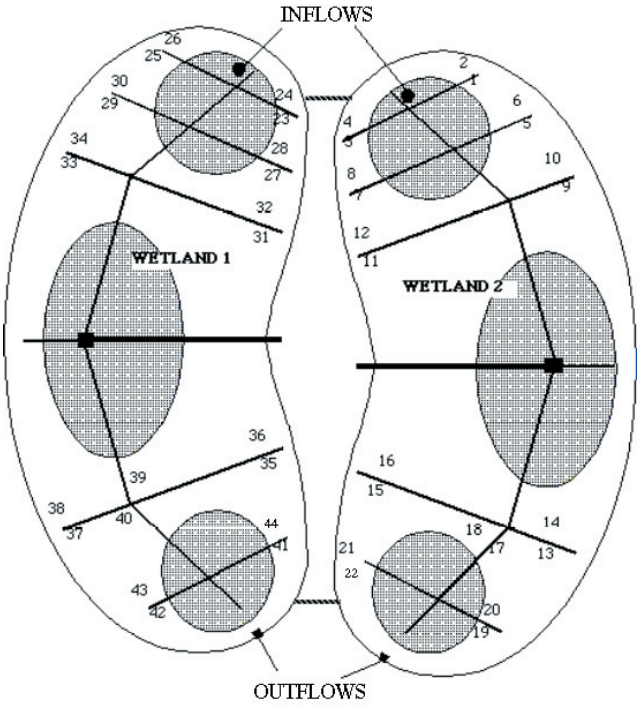

Figure 1. Potential sampling stations for macrophyte harvesting. Sixteen were sampled in Wetland 1 and 10 in Wetland 2 in 2003.

Results and Discussion

Comparison of Basins and Location

In 2003, macrophyte aboveground NPP was 432±60 $gm^{-2}yr^{-1}$ (Table 1). Productivity was 192±54 $gm^{-2}yr^{-1}$ for 10 sites in Wetland 2, a 63% drop in marsh productivity from 2002. The productivity at the outflow was significantly lower than the inflow for both Wetland 1 and Wetland 2 in 2003 ($\alpha = 0.05$), a pattern also seen in 2002 (Figure 2).

Dry/wet Ratios

As in the previous annual reports, dry/wet ratios of individual plants which are necessary for estimating NPP are provided (Table 2). Dry/wet ratios of dominant plants averaged 16% for *Schoenoplectus* in Wetland 1 but only 5% for the same species in Wetland 2. This difference reflects the overall vigor noticed of this species in the two wetlands. There was a similar lower dry/wet ratio determined

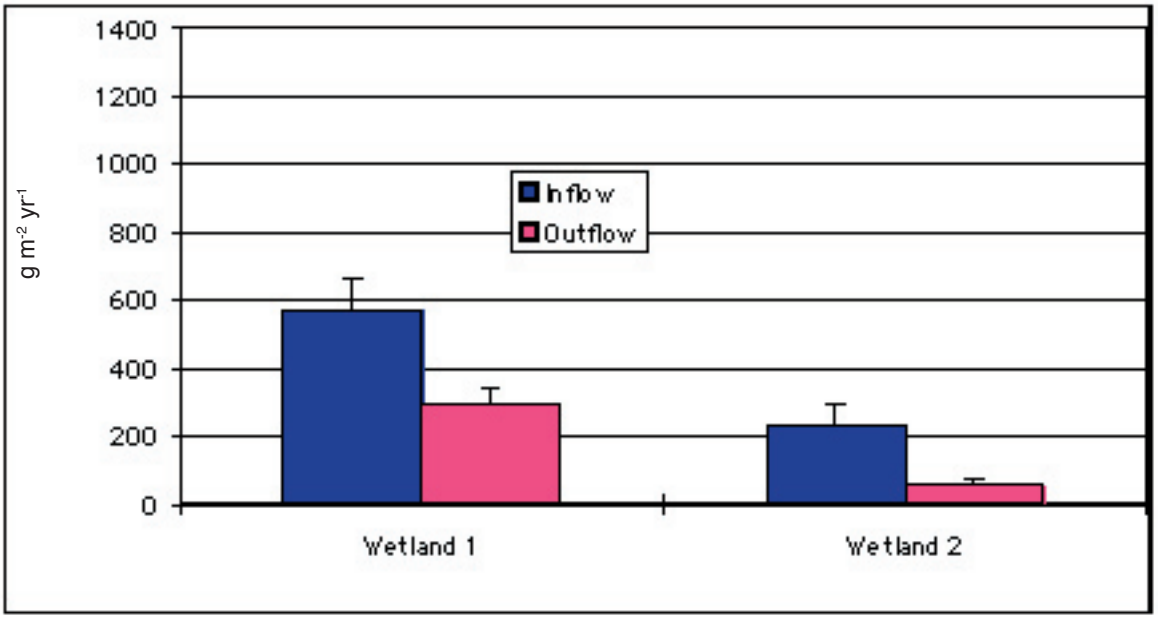

Figure 2. Aboveground net primary productivity in Wetland 1 and 2 in inflow and outflow areas for 2003.

Table 1. Estimated net above-ground primary productivity (NAPP) of macrophyte communities in the Olentangy River experimental wetlands based on peak biomass harvest, 1999 - 2003 Numbers are ave±std error [# samples].

Wetland/ Year	Total NPP, g m^{-2} yr^{-1}	Inflow NPP, g m^{-2} yr^{-1}	Outflow NPP, g m^{-2} yr^{-1}
Wetland 1			
1999	657±76 [16]	601±126 [8]	714±90 [8]
2000	482±64 [16]	597±87 [8]	368±79 [8]
2001	393±87 [9]	454±98 [7]	181±120 [2]
2002	689±93 [16]	915±126 [8]	462±79 [8]
2003	432±60 [16]	570±90 [8]	295±45 [8]
Wetland 2			
1999	1023±94 [16]	790±75 [8]	1256±130 [8]
2000	1013±105 [16]	882±126 [8]	1144±163 [8]
2001	832±85 [9]	746±76 [7]	1134±145 [2]
2002	519±64 [15]	699±84 [7]	361±53 [8]
2003	192±54 [10]	226±62 [8]	54±19 [2]

for *Typha* and *Leersia* in Wetland 2 compared to Wetland 1. This was the first year that such a difference in the ratio was seen between the two wetlands.

Comparison with Previous Years

Overall, macrophyte cover decreased significantly in both wetlands in 2003 compared to similar plot readings in 2002 (Fig. 3). When paired sites were compared between the two wetlands (16 sites were paired in 2003) macrophyte plot productivity was statistically higher in the planted Wetland 1 than in the naturally colonized Wetland 2 ($t = 0.0002$; α

Table 2. Dry/wet ratios (ave±std error (# samples)) of dominant macrophytes in the Olentangy River wetlands in 2001-2003.

Species/	Wetland 1	Wetland 2
Schoenoplectus tabernaemontani		
2002	0.15±0.01 (14)	0.16±0.02 (14)
2003	0.16±0.01 (14)	0.05±0.01 (7)
Polygonum sp.		
2002	0.16±0.01 (13)	0.15±0.01 (7)
Scirpus fluviatilis		
2001	na	na
2002	0.13±0.03 (3)	na
Sagittaria latifolia		
2002	0.07±0.01 (3)	na
Sparganium eurycarpum		
2001	0.16±0.03 (7)	na
2002	0.10±0.01 (10)	na
2003	0.15±0.01 (15)	na
Typha spp.		
2001	0.20±0.05 (2)	0.29±0.03 (9)
2002	0.14±0.03 (4)	0.21±0.04 (8)
2003	0.23±0.02 (5)	0.11±0.00 (3)
Leersia oryzoides		
2002	0.25±0.03 (10)	0.23 ± 0.02 (4)
2003	0.21±0.2 (15)	0.10±0.02 (6)
Cyperus sp.		
2002	0.15±0.01 (8)	0.21±0.02 (9)
Echinochloa sp.		
2002	0.13 ±0.03 (5)	0.17±0.04 (2)
Lycopus americanus		
2002	0.18±0.01 (2)	na
Ludwigia sp.		
2003	na	0.14±0.4 (2)

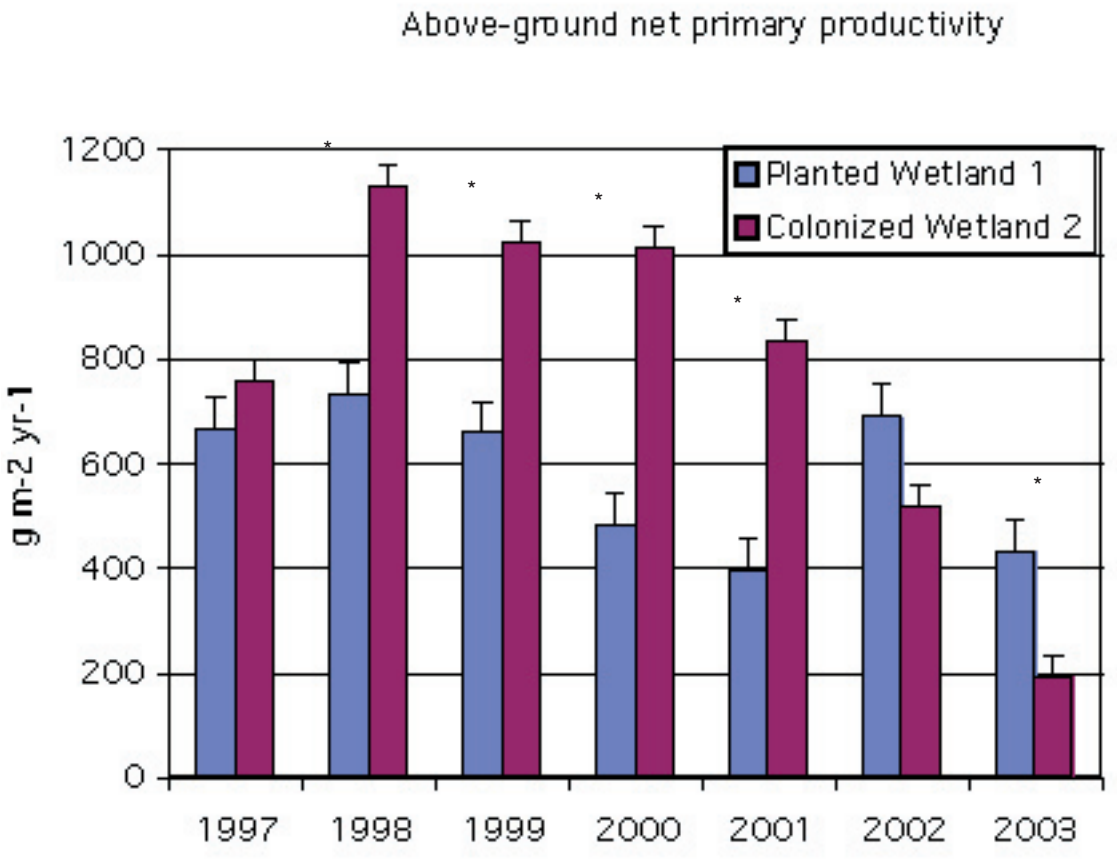

Figure 3. Aboveground net primary productivity for 1997-2003 in the experimental wetlands. * indicates significant differences between the two wetlands (α=0.05).

Table 3. Percent dominance of macrophytes by aboveground primary productivity in quadrats in 2002 (n = 16 for W1; n= 15 for W2) and 2003 (n = 16 for W1; n= 10 for W2) and species richness in quadrats. nd indicates not detected in biomass samples; 0.0 indicates presence but not significant contributor to productivity.

	2002		2003	
Species	W1	W2	W1	W2
Schoenoplectus t.,	72.8	55.9	36.7	37.3
Polygonum spp.	12.5	21.8	0.0	0.0
Typha spp.	6.9	16.1	16.3	41.9
Sparganium eury.	0.5	nd	18.0	nd
Leersia oryzoides	5.1	6.3	28.2	25.3
Cyperus sp.	1.9	5.7	0.0	nd
Echinochloa	0.6	0.4	0.0	nd
Panicum sp.	nd	0.2	nd	5.6
Lycopus sp.	0.5	0.0	nd	nd
Scirpus fluviatilis	0.5	nd	0.9	nd
Sagittaria latifolia	0.4	0.0	0.0	nd
Ludwigia palustris	0.0	0.0	nd	nd
Penthorum sedoides	nd	nd	nd	0.0
Gratiola virginiana	nd	nd	nd	0.0
Mimulus ringens	nd	nd	0.0	nd
TOTAL	100.0	100.0	100.0	100.0
species richness	11	10	10	7

= 0.05) for the first time in 7 years. NPP was significantly higher in plots in Wetland 2 than in Wetland 1 for 4 straight years from 1998 to 2001.

Species Dominating the Productivity

Macrophyte species that were found in the sample quadrats in 2002 and 2003 are listed in Table 3. Data for 2002 are corrected from data previously published (Mitsch et al., 2003). As was the case in previous years, the species harvested in the two basins indicate some differences that are still attributable to the planting of 1994. Wetland 1, which was planted with 12 species in May 1994, had four of those species still contributing to macrophyte productivity (*Schoenoplectus tabernaemontani*, *Sparganium eurycarpum, Scirpus fluviatalis,* and *Sagittaria latifolia). S. tabernaemontani* contributed 37% of the productivity in W1 and *Sparganium eurycarpum* added 18% of the productivity in 2003 (Table 3). Colonizing plants *Typha* and *Leersia* contributed 16 and 28% of the productivty in W1 in 2003.

S. tabernaemontani, which had restored itself in W2 during the spring drawdown from the seed bank in W2 in 2001, still accounted for 37% of the productivity of W2 in 2003.

Typha once again dominated the NPP in Wetland 2 with 42% of the productivity in 2003. Colonizing *Typha* provided 16% of the productivity in Wetland 1. Both were

significant increases in dominance compared to 2002 when *Schoenoplectus* dominated productivity in both basins. By contrast *Typha* contributed 41.4% of the productivity in Wetland 1 and 100% of the productivity in Wetland 2 in 2001. *Typha* lost dominance in both wetlands because of muskrat herbivory in the winter of 2001, followed by seed bank restoration and subsequent agressive growth by *Schoenoplectus* in 2002.

There were 10 macrophyte species found in the sampling plots in Wetland 1 and seven species in Wetland 2 in 2003 compared to 11 and 10 species seen in 2002 in Wetlands 1 and 2 respectively. *Lycopus* and *Ludwigia palustris* were seen in Wetland 1 in 2002 but not in 2003. One additional species, *Mimulus ringens*, was seen in plots for the first time in 2003 in Wetland 1. Two new species, *Penthorum* and *Gratiola* were observed in Wetland 2 plots in 2003 for the first time but five species—*Sagittaria*, *Cyperus*, *Echinochloa*, *Lycopus* and *Ludwigia*—were not seen in plots in 2003 after all were present in 2002 plots. Smartweed *(Polygonum* spp.) continued to be found in both wetland basins but was not nearly as prevalent in 2003 as it was in 2002, when it contributed 12 and 22% of the productivity respectively to Wetlands 1 and 2.

Basin Productivity

Based on the aboveground productivity estimates reported here and estimates of macrophyte cover presented elsewhere in this annual report (Mitsch and Zhang, 2004; W1 = 5,549 m^2; W2 = 3,253 m^2), aboveground productivity by macrophytes was estimated to be 2397 and 625 kg per year in Wetlands 1 and 2 respectively (Table 4). Overall macrophyte organic productivity decreased 46% in Wetland 1 and 81% in Wetland 2 from 2002 to 2003. These numbers are significant for two reasons. First, although the macrophyte community substantially recovered from the herbivory and subsequent macrophyte losses of 2000 and 2001 in 2002, productivity once more decreased in 2003, due to herbivory and possibly high water levels, especially in Wetland 2. This could be a result of the spring water pulsing in 2003. Second, 2003 is the second year in a row where the planted Wetland 1 had a higher esimated macrophyte carbon sequestration than the naturally colonized Wetland 2. The total organic matter production by macrophytes over the last 7-year period is now almost the same in the two wetland basins at 22-23 Mg per basin (Table 4).

Table 4. Estimated macrophyte above-ground net primary productivity in each experimental wetland, kg dry-wt per wetland basin, 1997-2003

Year	Wetland 1	Wetland 2
2003	2397	625
2002	4478	3330
2001	963	1250
2000	1960	4265
1999	5800	6800
1998	3300	3500
1997	2525	3040
Total	22,323	22,810

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